# Direct Osmotic Concentration (DOC)

## Background

Reverse osmosis (RO) is a favourable treatment for water purification as it has the advantages of:

* High rejection
* Durability
* Small footprint
* Simple to operate
* Minimal resupply for continuous operation

Despite all these advantages there is one major disadvantage. RO methods are prone to fouling, therefore require a pre-treatment to the feed to ensure there is an acceptable performance of the system. The DOC system is one of the purposed pre-treatment methods for RO.

## DOC System

The system that was purposed for a water purification system to be used by NASA consists of a RO core, with two DOC pre-treatment stages. DOC-1 uses direct osmosis and DOC-2 uses a combination of direct osmosis and osmotic distillation. It is this combination in DOC-2 that is able to remove small compounds, such as urea, that can easily pass through a semi-permeable membrane that is used in osmosis.

#### Direct Osmosis

In this direct osmosis (DO) system, a hypertonic solution is recirculated on the permeate side of the membrane. The wastewater is recirculated on the feed side of the membrane. The driving force for mass transfer across the membrane is the osmotic pressure difference. As long as the chemical potential of water on the permeate side is lower than water on the feed side then water will move through the membrane and enter into the permeate side.

From this it can be seen that most of the energy that is used in this process is involved in reconcentrating the osmotic agent that is used on the permeate side of the membrane. This reconcentration takes place in the reverse osmosis step.

**Advantages**

* Relatively low fouling potential
* Low energy consumption
* Simple
* Reliable

**Disadvantages**

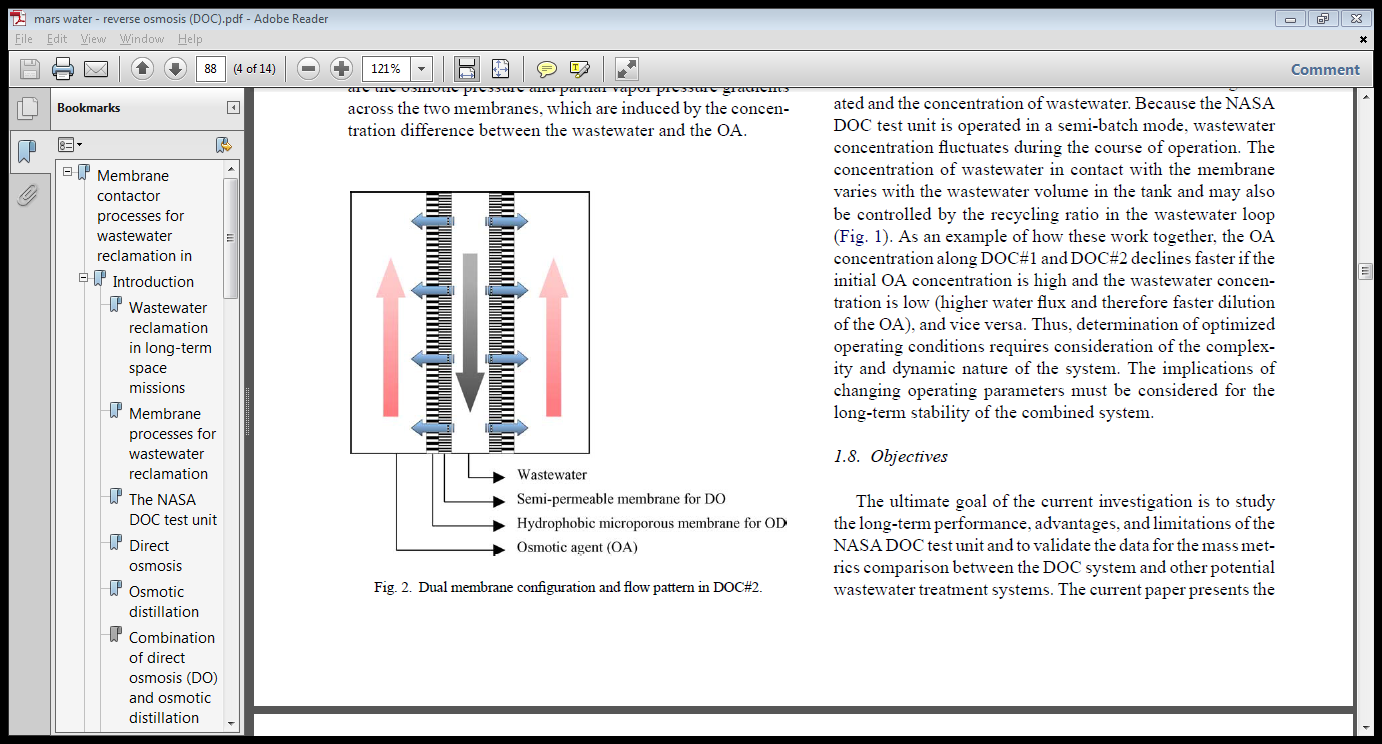
* There is a gradual loss of salt in the osmotic agent as it diffuses through to the feed side. This reduces the driving force of mass transfer over time. Membrane selection is key in reducing salt transfer to the feed stream, but maximising driving force of water into the permeate side.

#### Osmotic Distillation

The osmotic distillation (OD) that takes place here is an isothermal membrane distillation process, with the driving force being the partial vapour driving pressure gradient of water across a hydrophobic microporous membrane. This pressure gradient is induced by a concentrated salt solution, aka osmotic agent.

OD is good at rejecting small, non volatile molecules such as urea. Urea has a poor rejection in reverse osmosis, so removing it here prevents it becmong a problem. This OD is very sensitive to temperature changes, with the potential for a reverse flux being induced if there is a slight increase.

**Combination**

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Two membranes are placed side-by-side, one semi-permeable for DO and one microporous for OD. The mass transfer through these membranes occurs in 3 steps:

1. Water diffuses from the wastewater stream through the semi-permeable membrane
2. Water evaporates through the microporous membrane
3. Water condenses into the osmotic agent

Driving forces in this process are the osmotic pressure and the partial vapour pressure gradients across the two membrances.

## Comparison

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Technology | Weight (kg) | Specific Power (Wh/kg) | Volume (m3) | Resupply (kg/year) |
| ISS Baseline | 193 | 55 | 1.1 | 413 |
| DOC | 233 | 102 | 0.78 | 0 (20) |

## Diagram of DOC system

